VII. *Electrical Experiments by Mr.* Edward Nairne, *of* London, *Mathematical Inſtrument-maker, made with a Machine of his own Workmanſhip, a Deſcription of which is prefixed.*

Redde, Dec. 9, 1773. FIG. Iſt. [TAB V. and VI.] is a repreſentation of the machine, with its apparatus, as was uſed when electrical ſparks were drawn from the conductor, in a poſitive ſtate. The glaſs cylinder, of this machine, is 12 inches diameter, and the cylindrical part 19 inches long, excluſive of the necks; the cuſhion or rubber is 14 inches long, and 5 inches broad, ſupported by two wooden ſprings; which ſprings are fixed on two glaſs rods, which lie horizontal under the cylinder, and ſerve to inſulate the cuſhion. The conductor to this machine is 5 feet long, and 12 inches diameter; at the end of it is a ſhort braſs rod, with a ball; it is ſupported on two ſtands, with ſolid glaſs rods or pillars. The ball, which is repreſented as receiving the electrical ſpark from the conductor, is of braſs, and fixed to the end of a braſs tube, which tube is moveable, in a hole in the top of the receiving ſtand; from the bottom of this ſtand a chain paſſes along the floor, till it is

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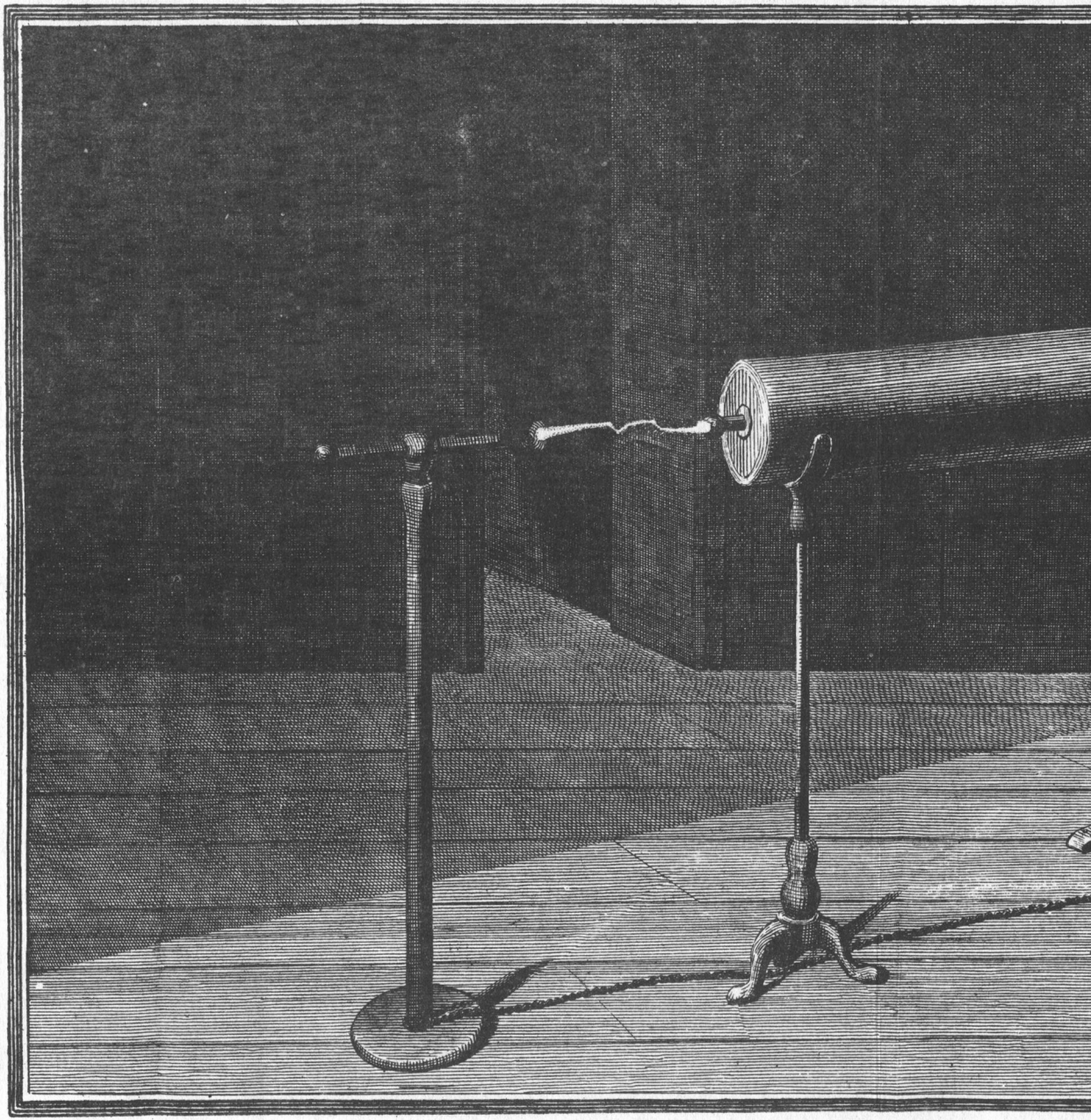
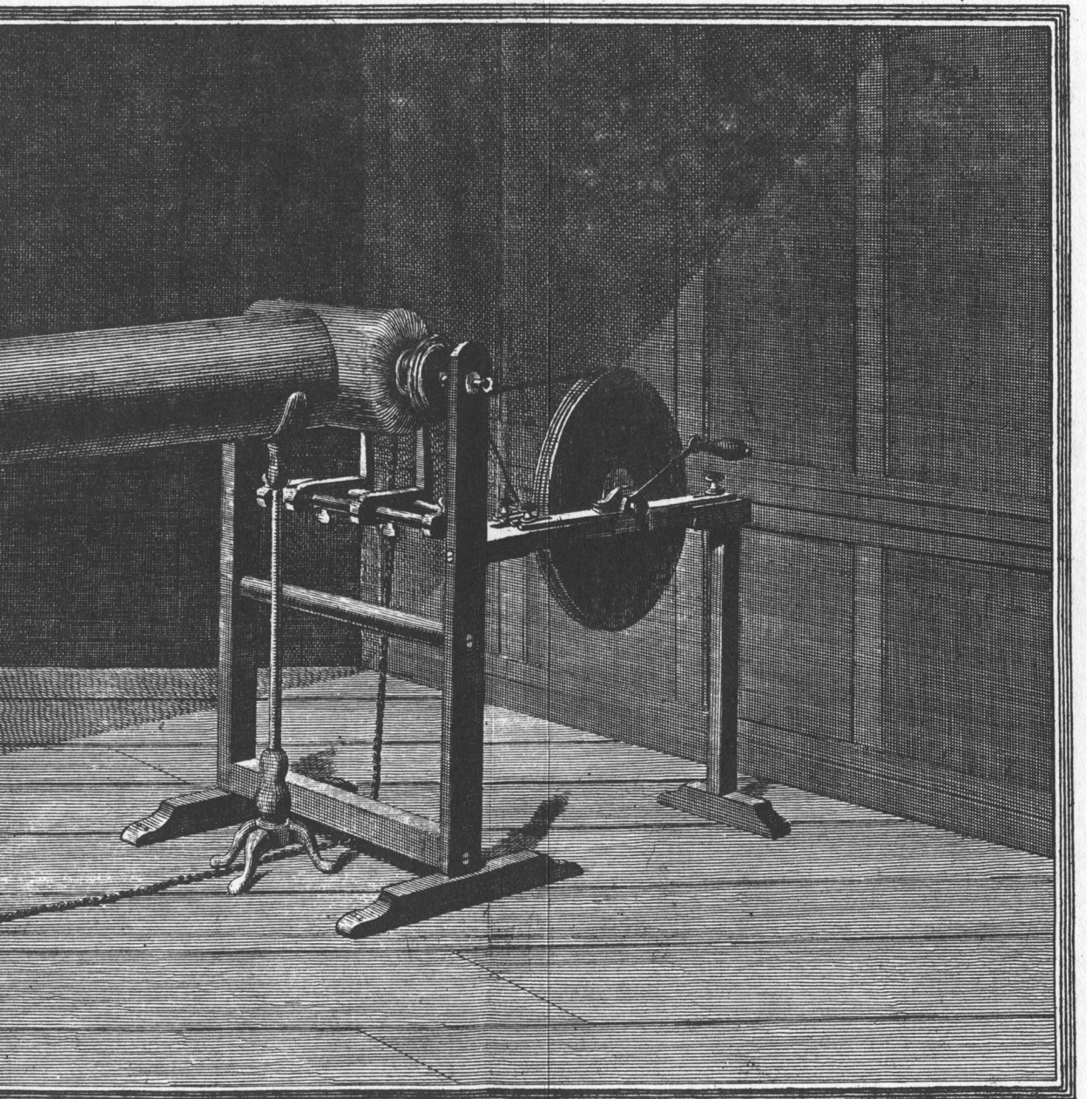
in contact with the chain hanging from the back of the cuſhion, as is repreſented in the figure. With this machine I have frequently drawn electrical ſparks, at the diſtance of 12, 13, or $13\frac{1}{2}$ inches from the prime conductor. Theſe were indeed the diſtances, to which the electrical fire would commonly ſtrike. It would ſometimes reach the diſtance of 14 inches; but this was but ſeldom.

Fig. II. repreſents the ſame machine, with a ſmall braſs conductor, inſtead of the large one, for charging the batteries, which batteries are compoſed of four boxes, each containing 16 jars of 12 inches high and 4 inches diameter, coated 8 inches high; ſo that, in the 64 jars, there are very nearly 50 ſquare feet of coated ſurface. The electrometer * is raiſed, ſo as to be 4 feet from the bottom, which reſts on the jars, to the ball at top. I at firſt ſet it on the battery, ſo that the ball, at the end of the Index, was about one inch higher than the balls or wires of the battery, which is the general method of uſing it; but I found, on placing it ſo low on theſe batteries, that the index would move but a very little way, hardly to 15°, when the battery was full charged; at laſt, after trying a great variety of experiments, I found, that, placing it at the height of 4 feet, the index would riſe to 60, with the ſame quantity of charge as, in the other caſe, raiſed it only to 15: diſcharging this battery, through a piece of *iron* wire (not ſteel) of $\frac{1}{151}$ of an inch diameter, and three feet nine inches long, it flew about the room in innumerable red hot balls; on examining theſe balls, they were in

* Vide Phil. Tranſ. Vol. LXII. p. 359.





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general hollow, and ſeemed to be nothing but ſcoria. The drawing is a repreſentation of diſcharging the battery through the wire. I have made a piece of the ſame wire, of 3 feet 11 inches long, red hot, from end to end, ſo that it ſeparated into ſeveral pieces. After this, I took a piece of the fine iron wire beforementioned, of ſix inches in length, and, to the end of it, connected a piece of iron wire $\frac{1}{2\frac{1}{5}}$th of an inch in diameter, and 48 feet long. Then, on diſcharging the battery, the electrical fire from the inſide paſſed immediately along the diſcharging rod to the fine wire, and afterwards had 48 feet to paſs, to get to the outſide coating of the battery: I then laid another piece, ſo that the electrical fire paſſed 48 feet, from the inſide of the battery, before it came to the ſmall wire; and again another, ſo that the electrical fire paſſed from the inſide of the battery 24 feet, before it came to the fine wire, and had 24 feet afterwards to paſs, before it could get to the outſide coating of the battery; in each caſe, the 6 inches of the ſmall wire was melted into red hot balls; and I could not perceive, that there was the leaſt difference, in the melting of the wire, on its being placed in different parts of the circuit. Next, I connected to a piece of the ſame fine iron wire, of 6 inches in length, a piece of the iron wire $\frac{1}{2\frac{1}{5}}$th of an inch in diameter, and in one continued piece of 274 feet in length. In this arrangement, when the battery was diſcharged, the electrical fire paſſed immediately from the diſcharging rod to the fine wire, and had 274 feet to paſs afterwards, to get to the outſide coating; then the fine wire was laid next the outſide coating of the battery, ſo that the

electrical fire paſſed 274 feet, before it reached it. This experiment was repeated ſeveral times, with this difference, that before every diſcharge of the battery I ſhortened the fine wire, till, at laſt, there was but half an inch of it connected with the 274 feet of wire; but even that ſhort piece was not made red hot by the diſcharge of the 64 jars. The electrical fire, in paſſing that 274 feet of wire, though it was one entire piece without any joinings, ſeemed to meet with great reſiſtance, for the exploſion from the battery was not ſo loud, as when a very ſmall electrical bottle is diſcharged. Next, I took ſome ſilver thread, and made a circuit, of 40 feet, from the inſide of the battery to the outſide; and, at the diſtance of about 12 feet from the battery, I held the ſilver thread between my finger and thumb, ſo that the electrical fire, paſſing along the thread, paſſed between them; on diſcharging the battery, I received a ſmart ſhock, particularly in both my ancles, though the thread was held three feet and a half from the dry floor, on which I ſtood: by the electrometer, the battery did not appear to be half diſcharged. Then I made a circuit, of 40 feet, with iron wire $\frac{1}{25}$th of an inch in diameter, and this was held in the ſame manner as the ſilver thread; on diſcharging the battery through the iron wire, there was not the leaſt ſhock felt, though the whole of the battery was diſcharged, the iron wire of that length conducted it ſo perfectly.

Then I tried the effect of the battery on ſome *platina*, which came from Doctor Lewis, of Kingſton; ſeveral of the grains, or *laminæ*, were laid

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on a piece of white wax, ſo as to make a length of half an inch; this method being recommended by my ingenious friend Mr. HENLEY, F. R. S. who had before uſed it with ſucceſs. On diſcharging the battery through the platina, I found, that not only the ſurface of ſome of the *laminæ*, or grains, had been in fuſion, but that part of it was melted in beautiful white ſpherules, viſible to the naked eye.

Another experiment that I tried, was on a duck; a chain was faſtened to its legs, and, holding it by the wings, the head was brought up to one of the rods of the battery, ſo that the battery was diſcharged through it, from the head to the feet; the conſequence was, the duck was thrown into violent convulſions, and expired in two or three minutes. Then I took a turkey, and faſtened a wire round its neck, and another on its rump, in ſuch manner, that the neareſt diſtance between the wires was along the back bone, thinking the charge of the batteries might paſs down the ſpine, and that the turkey would be made paralytic; but, on diſcharging the battery, the turkey opened its bill, and died inſtantly. Then I took a cock, and faſtened a wire on his rump, and placed one of the balls, of the diſcharging rod, on the middle of his back, ſo that the charge might not paſs near his vital parts; the battery being diſcharged, the body of the cock was violently agitated, for about half a minute, and the head was turned, ſo that the bill came againſt its breaſt; the head and neck however ſoon recovered, ſo that it moved its neck, to all appearance, as well as it did before it

was ſtruck; but the body was quite motionleſs, for about twenty minutes; after that it recovered very faſt, and, in about ten minutes more, was able to ſtand, and walk a little. After this, I put a wire round its neck, in the ſame manner as on the turkey; the effect was exactly the ſame; for, on diſcharging the battery through it, it died inſtantly. The wire, that conducted the electrical ſtroke which killed the turkey and cock, was $\frac{1}{25}$th of an inch in diameter.

The next experiment I tried was on ſome plants. I diſcharged the battery through a branch of a balſam, and examined it very attentively immediately after it was ſtruck, but could not perceive, that there was the leaſt alteration in the branch, till about ten or fifteen minutes after; and then the upper part of the branch began to droop its head, and continued drooping it, till it hung quite ſtrait down, and in two or three days entirely withered, though the other part of the plant was very vigorous, and did not appear to be in the leaſt affected; this experiment I repeated, ſeveral times, on ſeveral balſams, and always found the ſame appearances. I next tried the effect of the battery on a privet tree: what led me to try it, was the appearance, that I had often obſerved in trees, more particularly this ſummer, that ſome of their branches were deprived of all their leaves, while the reſt of the tree was in a very flouriſhing ſtate, and that many trees had loſt all their leaves before the uſual time; it ſtruck me, that this might poſſibly be cauſed by lightning; I therefore reſolved to try, whether I could pro-

duce a ſimilar appearance; accordingly I diſcharged the battery through a branch of the privet tree, without the leaſt apparent injury to the branch, at that time; but after three weeks, or thereabouts, the leaves of that branch, as far as the electrical fire had paſſed, began to wither and drop off, ſo that, about a month after it was ſtruck, it had juſt the appearance of the branches of the trees beforementioned; and the reſt of the tree was in a flouriſhing ſtate, and did not appear to be the leaſt hurt. The index of the electrometer, in all the beforementioned experiments, was raiſed to 60°.

September 14, 1773, the following experiments were made, in the preſence of Mr. BANKS, and ſeveral other members of the ROYAL SOCIETY, upon the undermentioned plants, which Mr. BANKS procured to be brought in pots, in a healthy, and moſt of them in a flowering ſtate; theſe were a female balſam, a marvel of Peru, a cardinal flower, an African geranium, a laurel, and a myrtle. Theſe plants were ſo diſpoſed, that a part only, of each, lay within the electric circuit; which part was carefully diſtinguiſhed, by a piece of thread tied juſt below it. The electrometer being raiſed to 60°, the battery was diſcharged, and the effect was, that, in proportion as theſe vegetables were herbaceous and ſucculent, the ſooner the parts of them, through which the ſhock paſſed, were obſerved to decay. Thus the main ſtem of the balſam, though, before the ſtroke, perfectly erect, drooped in a few minutes, and was quite dead the next morning; notwithſtanding that the other ſtems of the ſame plant, which were not within the circuit, continued in flower;

flower; and as a proof that the injury was local and partial, the plant, is yet alive, (November 15.)

The marvel of Peru and Geranium, ſuch parts of them as were ſtruck, were dead the next day, though the other parts ſtill continue alive.

The cardinal flower, much leſs ſucculent than any of the former, ſeemed for ſome days to have ſuffered in its flowers only, which withered the next day after the ſtroke, though the flowers of the other ſtems, and which were not ſtruck, went through their uſual courſe: in a few days however the leaves changed their colour, as well as the ſtem, and died; after which, the ſtem became perfectly dry; the other ſtems did not ſuffer in the leaſt.

It was a fortnight after the ſtroke, before the branch of the laurel, through which the electricity was directed, gave any indication of its being injured; ſoon after, however, the leaves changed their colour, dropped off, and the branch died; the reſt of this ſhrub is in perfect health.

For near a month the whole myrtle continued without any ſeeming injury, ſince which time ſeveral of the ſprigs near its top have died; and though it was ſo long before the injury received declared itſelf, yet the miſchief to this myrtle was more extenſive, than it was to any other of the vegetables expoſed to theſe trials.

Dr. WATSON, who has very long been converſant in electrical enquiries, was preſent at theſe experiments; he took the plants abovementioned under his care, and uſed his beſt endeavours for their preſervation, in order to obſerve, with the greater exactneſs, the progreſs of the effects of theſe electrical ſtrokes.

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From theſe experiments we find, that electricity, accumulated to a certain degree, puts an end to vegetable as well as animal life.

After having recited theſe experiments, I would beg leave to mention a caution, which may be of ſervice to future electricians who may uſe large batteries.

It is, never to diſcharge their batteries, if it is through a ready conductor, without the charge paſſes at leaſt five feet from the inſide of the battery to the outſide; by making uſe of this precaution, which I learnt from experience, I have diſcharged the beforementioned battery near one hundred times, and have never, ſince I have uſed that precaution, broke a ſingle jar by the electrical diſcharge, before which I was continually breaking them, by diſcharging the battery in the common method. There is another experiment, which I would wiſh to mention, as it probably may give ſome light in reſpect to balls, or points, for conductors, for buildings or ſhips: the apparatus and manner of trying the experiment, is as follows; in fig. 3. A repreſents the end of the large conductor of the electrical machine; B a braſs ball ſcrewed into the end of it, of one inch and nine tenths diameter; C a ſmall conductor, which was 5 feet 11 inches long, and one inch and four tenths diameter; it was made of wood, covered with tin-foil, and was inſulated, by being ſupported on a ſtand, the part D of which was of ſolid glaſs. The ball E, at the end of this conductor, was three inches diameter, and the ball F one inch and nine tenths diameter; under this ball, F, was a ſtand, G, made of wood covered with tin-foil, which had a moveable

moveable part, H, which might be raiſed higher or lower. On the top of this moveable part was ſcrewed either a pointed wire, or a wire with a ball $\frac{1}{4}$th of an inch diameter, and from the bottom of this ſtand a chain paſſed along the floor, till it was connected with the chain, which hung from the cuſhion; then I placed the conductor C, ſo that the ball E was four inches diſtance from the ball B, and having ſcrewed into the top of the moveable part, H, of the ſtand, G, a pointed wire, I moved it till the point was directly under the ball F, at the diſtance of 3 or 4 inches; and, on exciting the electrical machine, the fire paſſed from the ball B, to the ball E, and, almoſt at the ſame inſtant, ſtruck on the point from the ball F. I increaſed the diſtance ſlowly between the point and the ball, F, till I found the utmoſt diſtance, to which it would ſtrike to the point, which was ſix inches; I continued to move the point to nine inches diſtance or more; it then was luminous, and the fire continued to ſtrike, from the ball B, to the ball E, which ſhewed that the point carried off all the electrical fire from the conductor, C, otherwiſe it would not continue to ſtrike from B to E. Then I removed the point, every thing elſe remaining as before, and, in its ſtead, placed, a wire with a ball of $\frac{1}{4}$th of an inch diameter, at the top of it, at the diſtance of 3 or 4 inches, directly under the ball F, in the ſame manner as the point; then, on encreaſing this diſtance ſlowly, the electrical fire was found to ſtrike to the ball at nine inches, which is half as far again as to the point, and with this remarkable difference, that the quantity of fire was much greater, and the exploſion

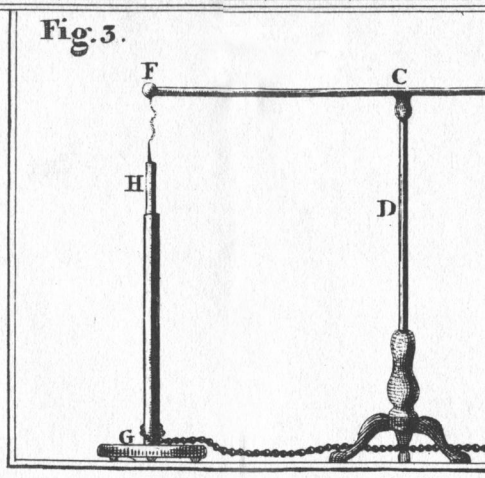
ploſion much ſtronger and louder, at its ſtriking the ball, than at its ſtriking the point.

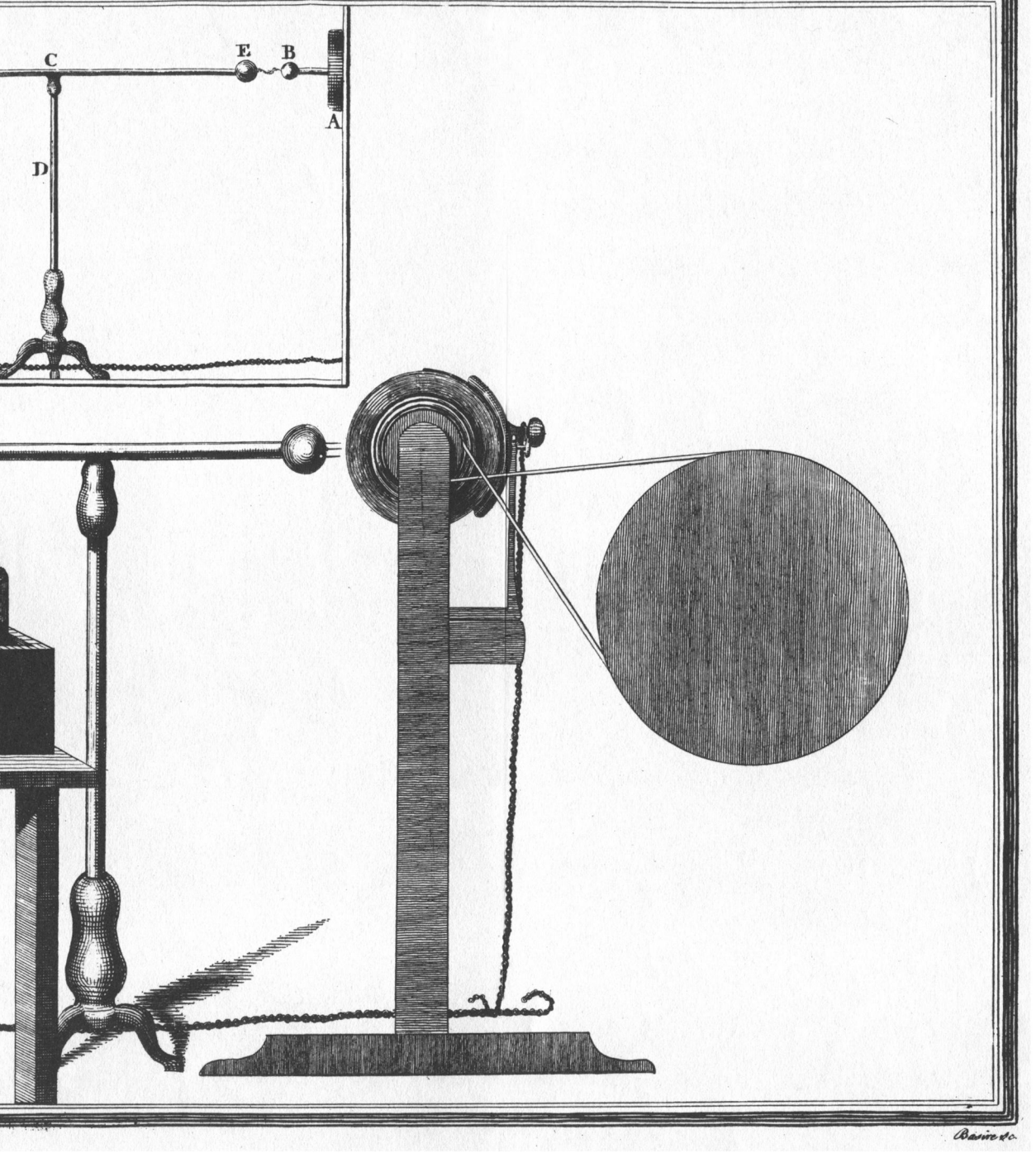
It may here be obſerved, that a point cannot poſſibly be placed in circumſtances more unfavourable, than theſe, to its operation *as a point*: the body of electric fluid falling upon it almoſt inſtantaneouſly, with the ſtroke from B to E, ſo that it had ſcarce any meaſurable time, wherein to act, as a point, in diminiſhing the quantity, before the whole fell upon it as upon a conductor. In the uſe of points to receive and conduct lightning, they generally act on the electrical atmoſphere of a cloud, while the cloud is yet at a diſtance, diminiſhing gradually that atmoſphere, before the cloud approaches near enough to give the ſtroke, and thus diminiſhing the ſtroke, if not quite preventing it. If the ſmall conductor, C, is placed ſo as to be in contact with the large conductor, A, inſtead of being four inches diſtant, as before, the electrical fire will not ſtrike to the point at any diſtance whatever; but the point will carry off ſilently all the electrical fire from the conductors, as faſt as the cylinder ſupplies them, even if the point is placed at the diſtance of ten inches or more.

I am afraid I ſhall have tired you with this minute detail; but I have been thus particular, that any Gentlemen may ſatisfy themſelves of the truth of theſe experiments.

To this machine there was another large conductor, 12 inches diameter, and five feet long, which being applied with its points to the back of the cuſhion, the machine was either negative or poſitive, only by hanging a chain on either conductor.

Fig. 2





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